Measurements of Black Carbon and Organic Carbon Influenced Solar Heating from Forest Fires in California Using Unmanned Aircraft

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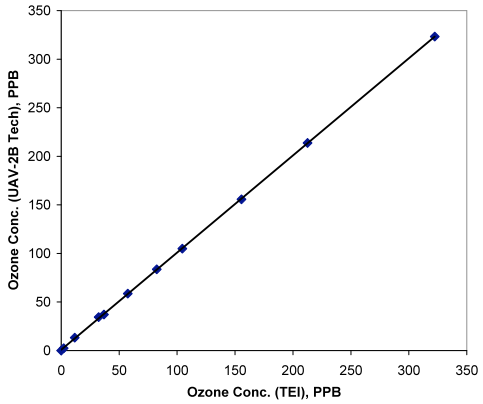
CAPPS

(California AUAV Air Pollution Profiling Study)

- Collect a seasonal record of aerosol, black carbon and ozone pollution concentrations from surface up to 12,000 feet asl.
- Look at the impact of pollution layers on radiative forcing to quantify the amount of solar dimming and heating rates.
- Funded by California Energy Commission.



New Miniaturized Ozone Inst funded By CEC

CAPPS Stacked UAV Flight Configuration

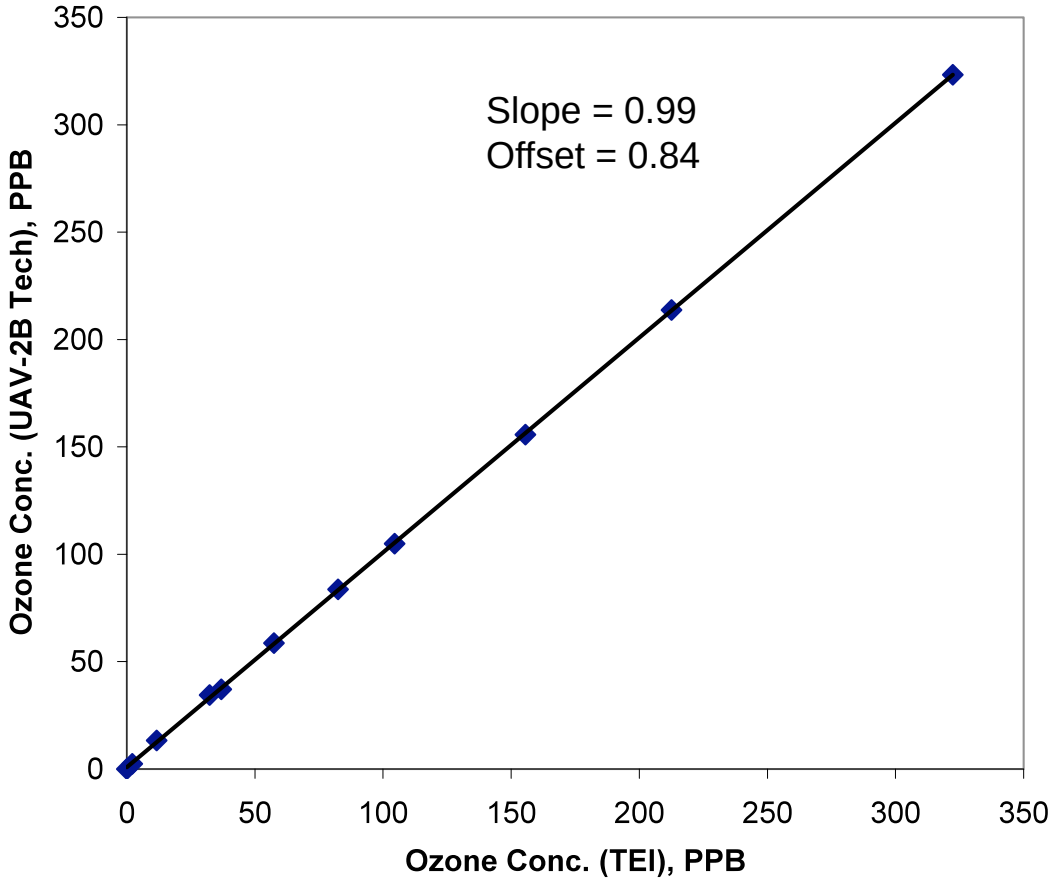
3 km agl

1 km agl

Measurements for CAPPS

- Aerosol Number Concentration
- Aerosol Size Distribution (0.3 – 3 μm)
- Black Carbon/Aerosol Absorption
- Ozone
- Solar Flux (Visible and Broadband)
- Temperature, Pressure, Relative Humidity

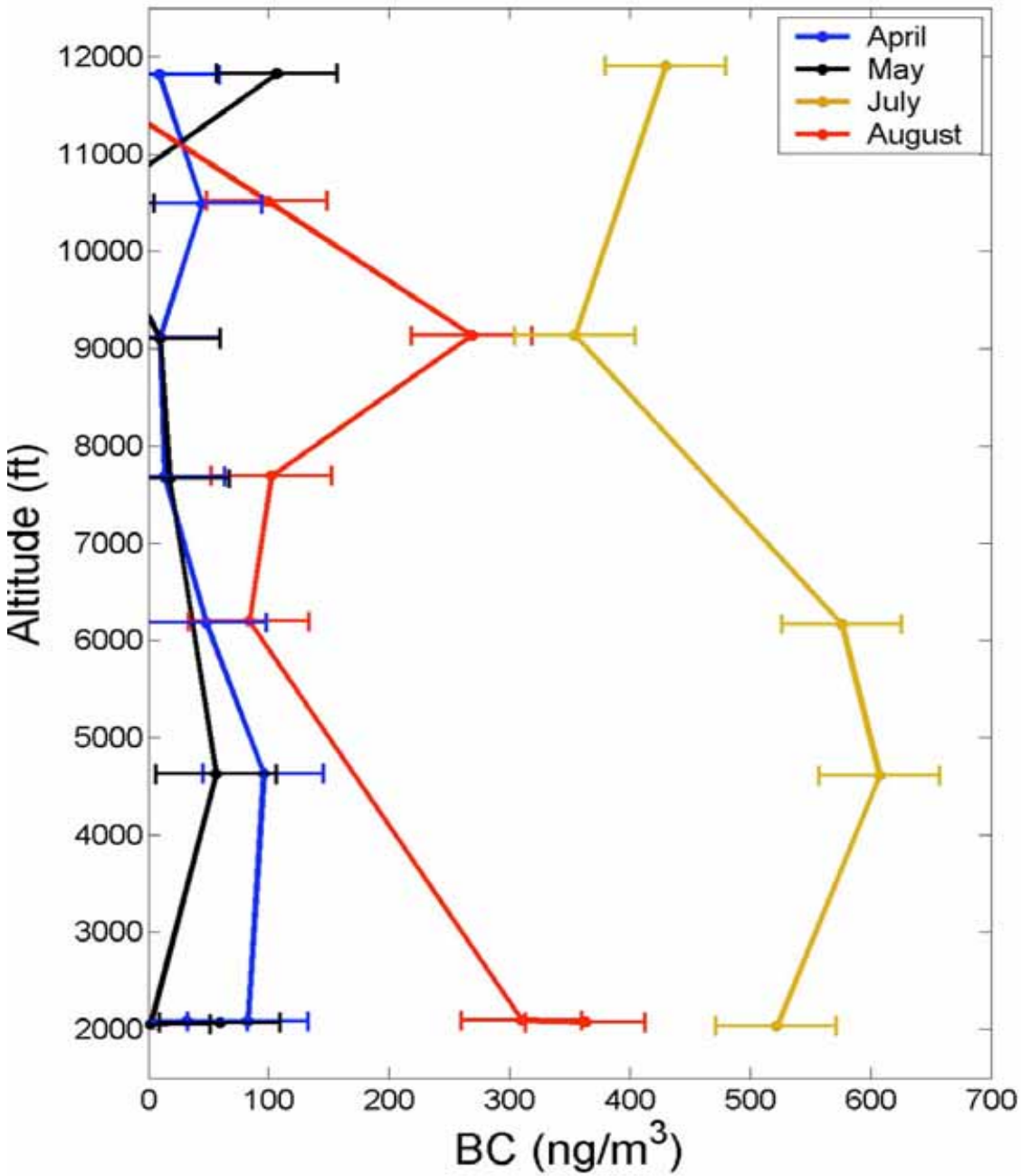
UAV Ozone Instrument



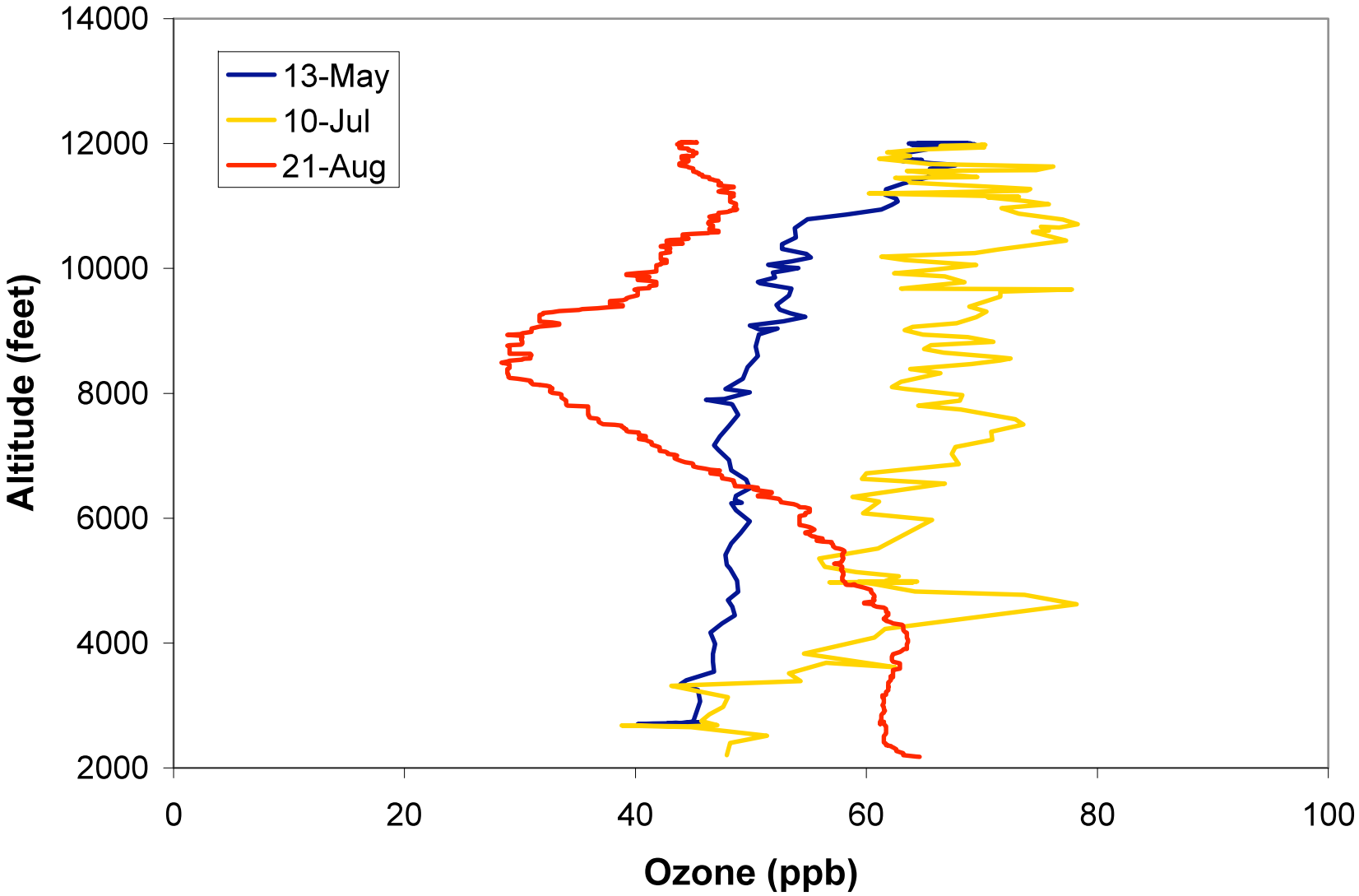
Sampling Site – NASA Dryden

Edwards Air Force Base in Mojave Desert

Black Carbon Concentration Vertical Profiles



Ozone Concentration over NASA Dryden



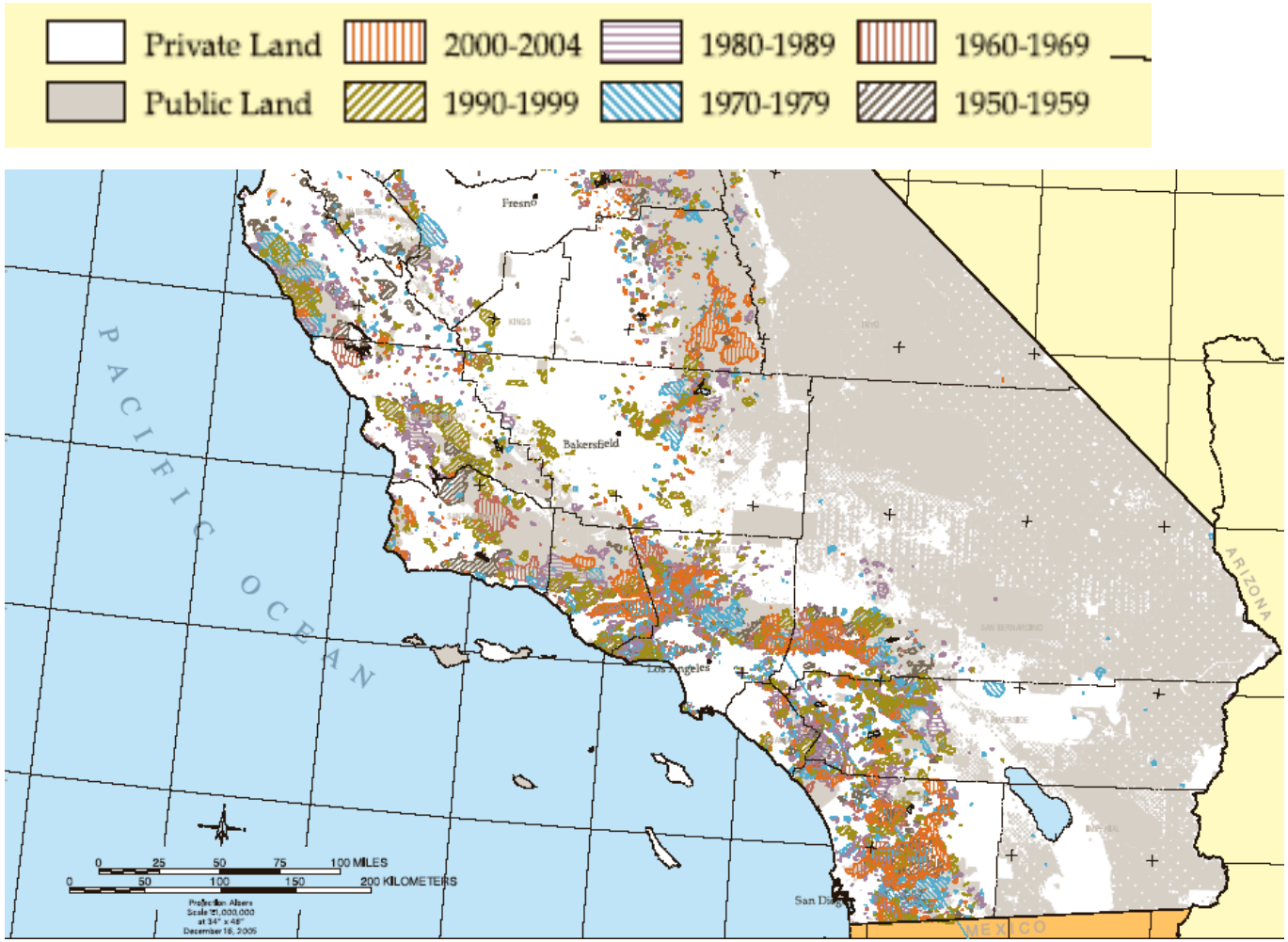
Climate effects of wildfires

- Wildfire frequency and intensity may be driven by climate change (Westerling et al, 2006)

- Wildfires account for 5% of total CO_2 and 15% of the emitted black carbon in the USA (Liu et al, 2004, Bond et al, 2004.)
  (both percentages higher in California).

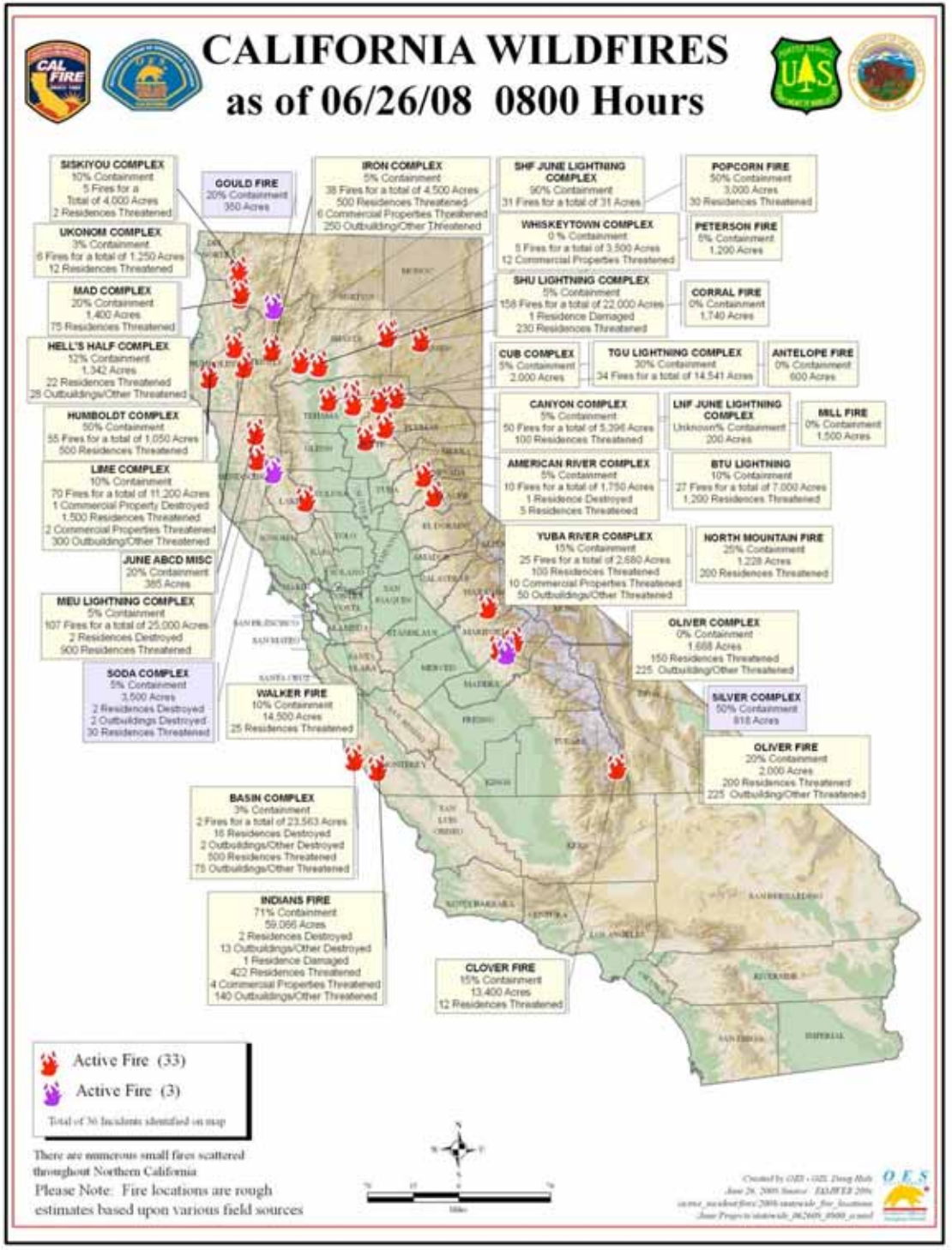
- **Gas and particulate emissions from wildfires have an effect on radiative forcing.**

Wildfires over the last 50 years



CA Department of Forestry and Fire Protection

High number of simultaneous wildfires in June-July 2008



Wildfires are a significant local source of black carbon for summer and fall season.

(Two weeks prior to flight.)

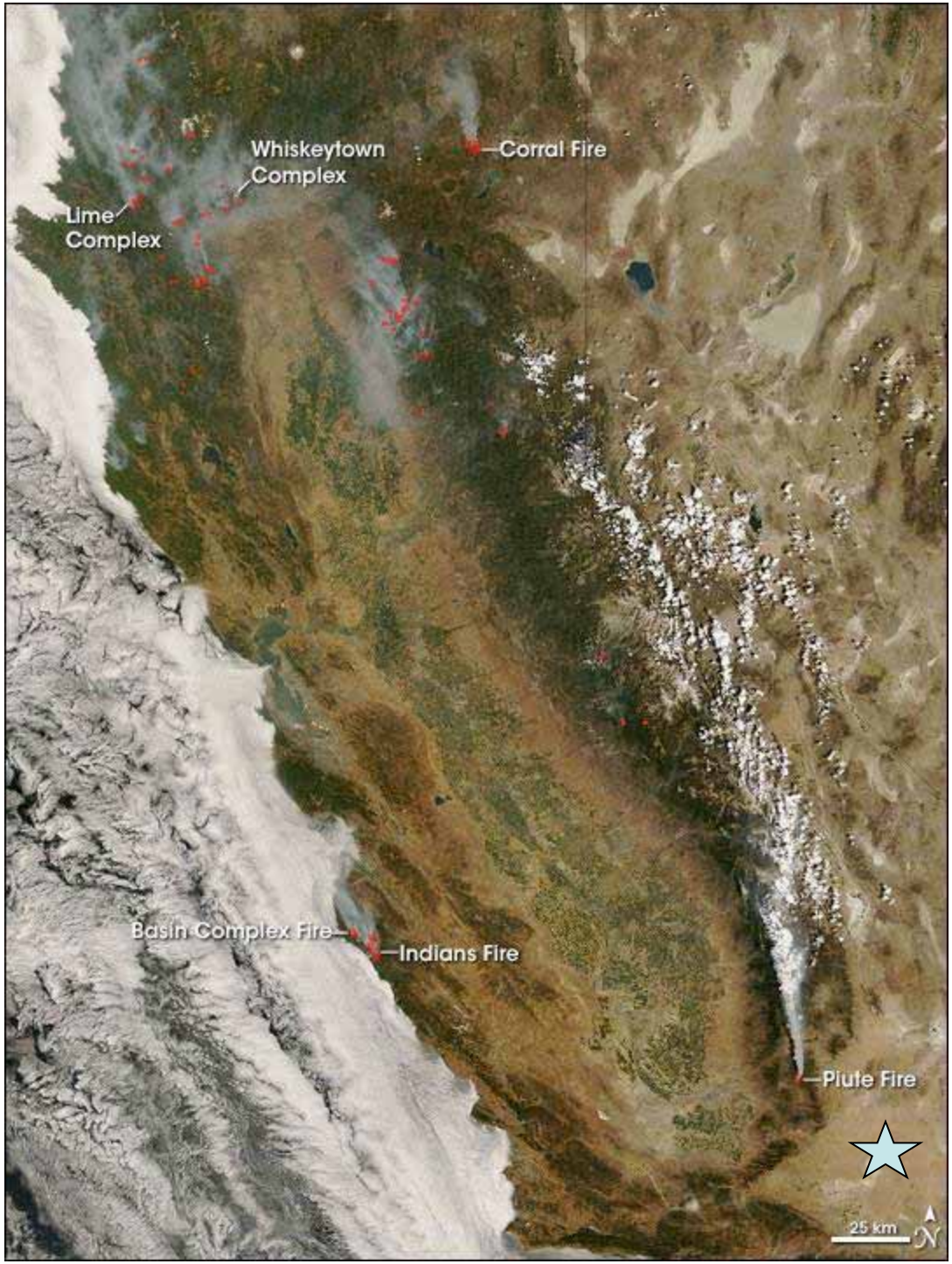


Image from NASA Earth Observatory June30, 2008

The smoke plumes persist 11 days later.

(Day of flight)

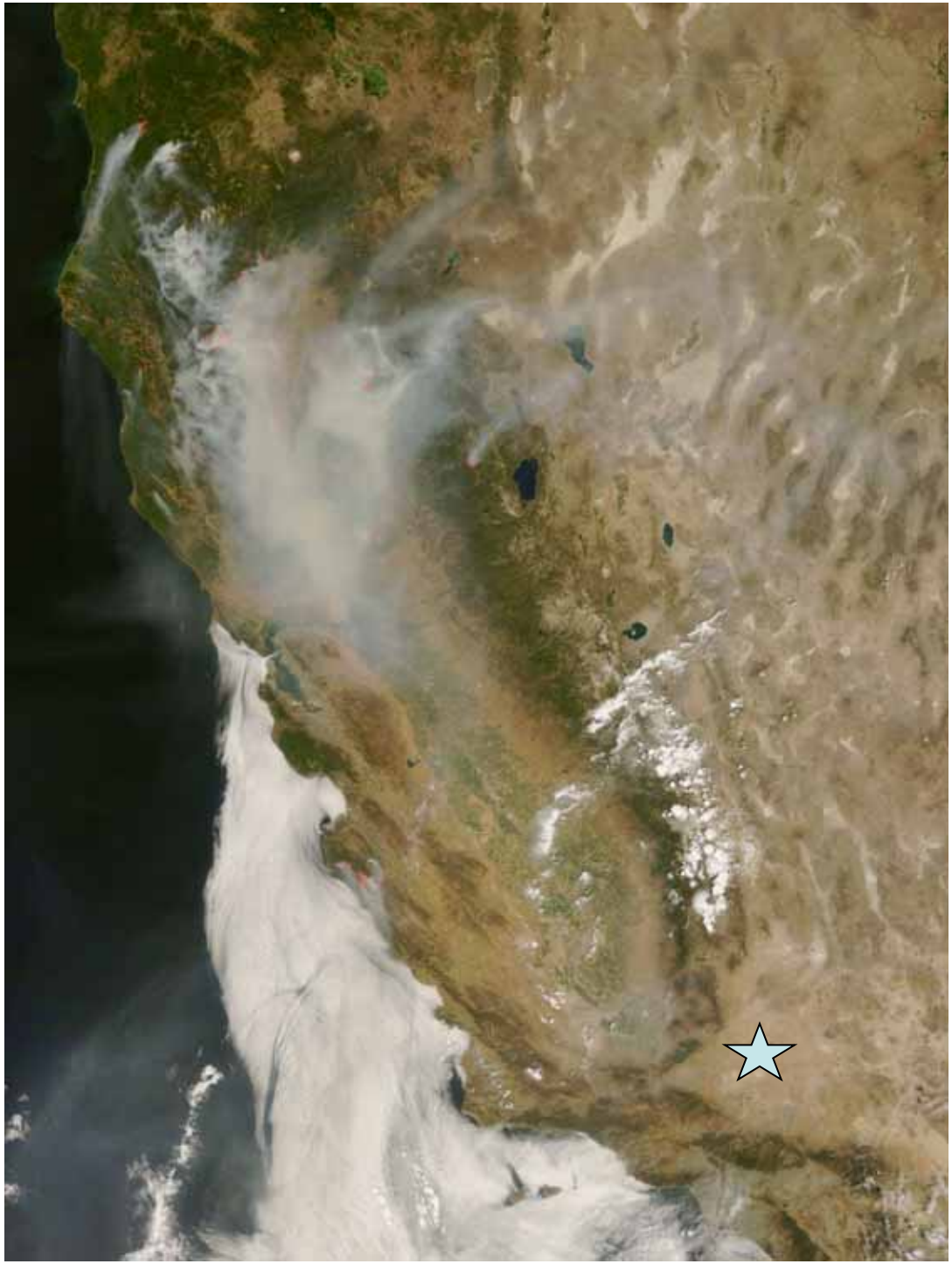
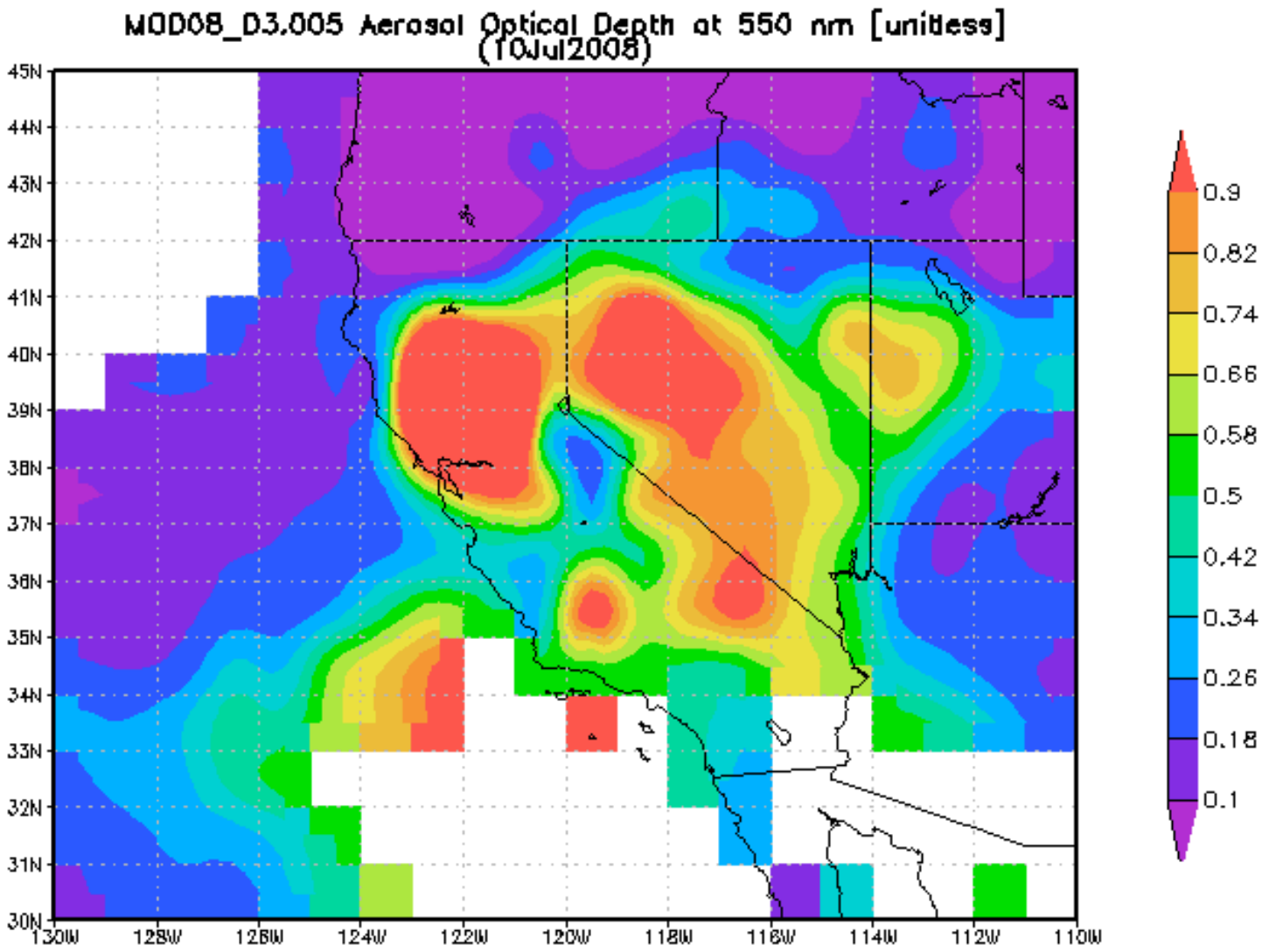
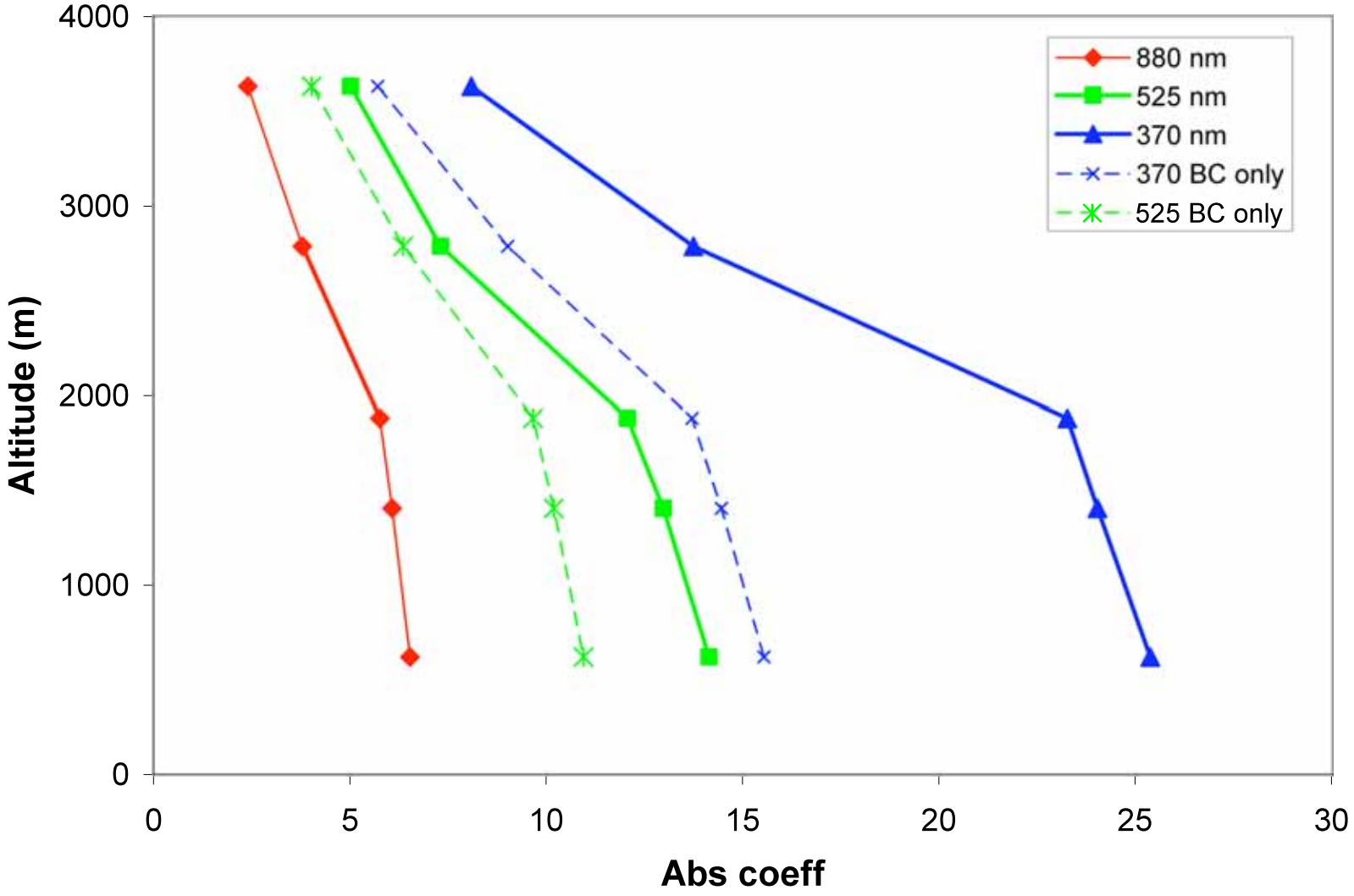


Image from NASA Earth Observatory July 10, 2008

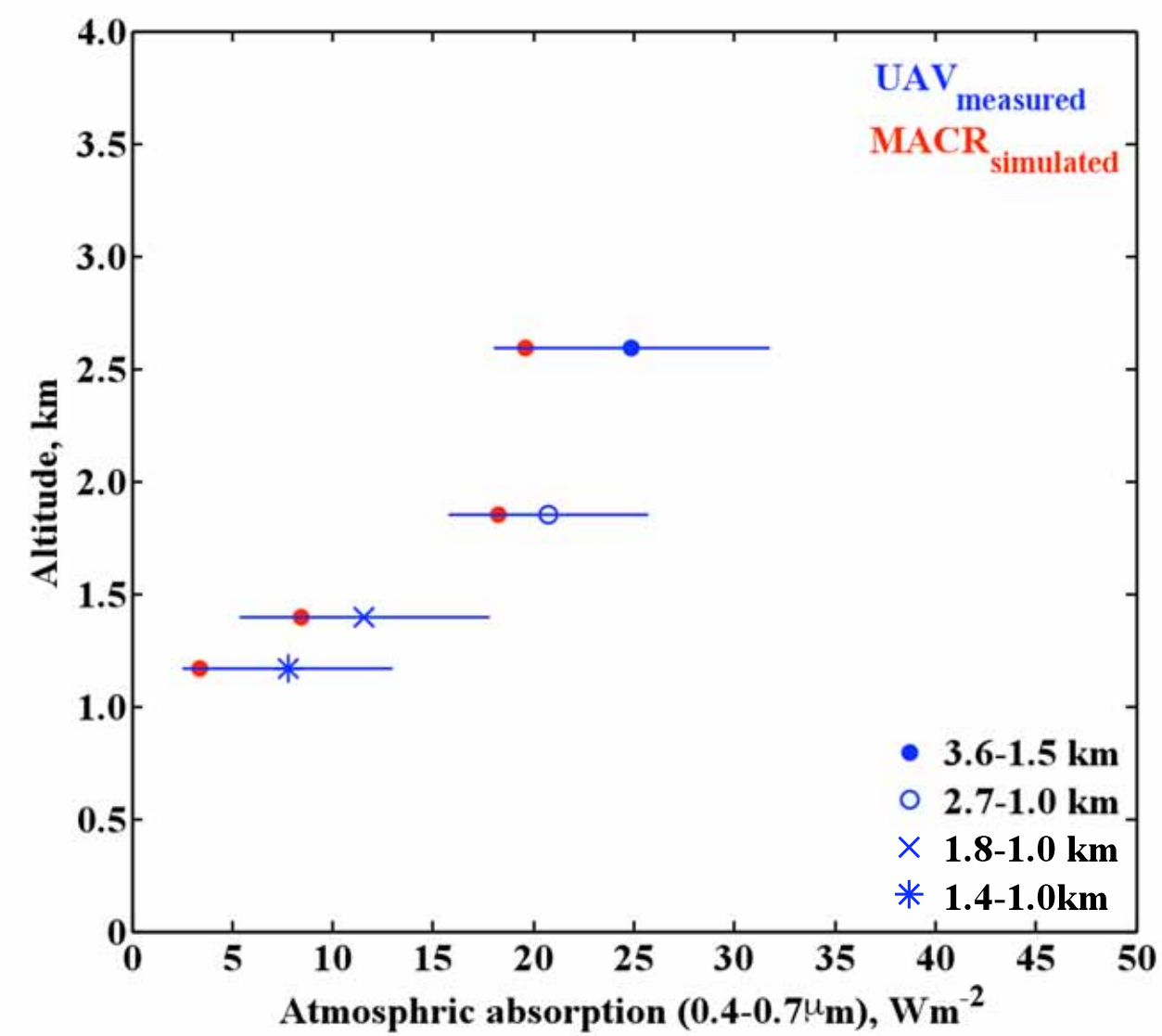
Aerosol optical depth on July 10, 2008



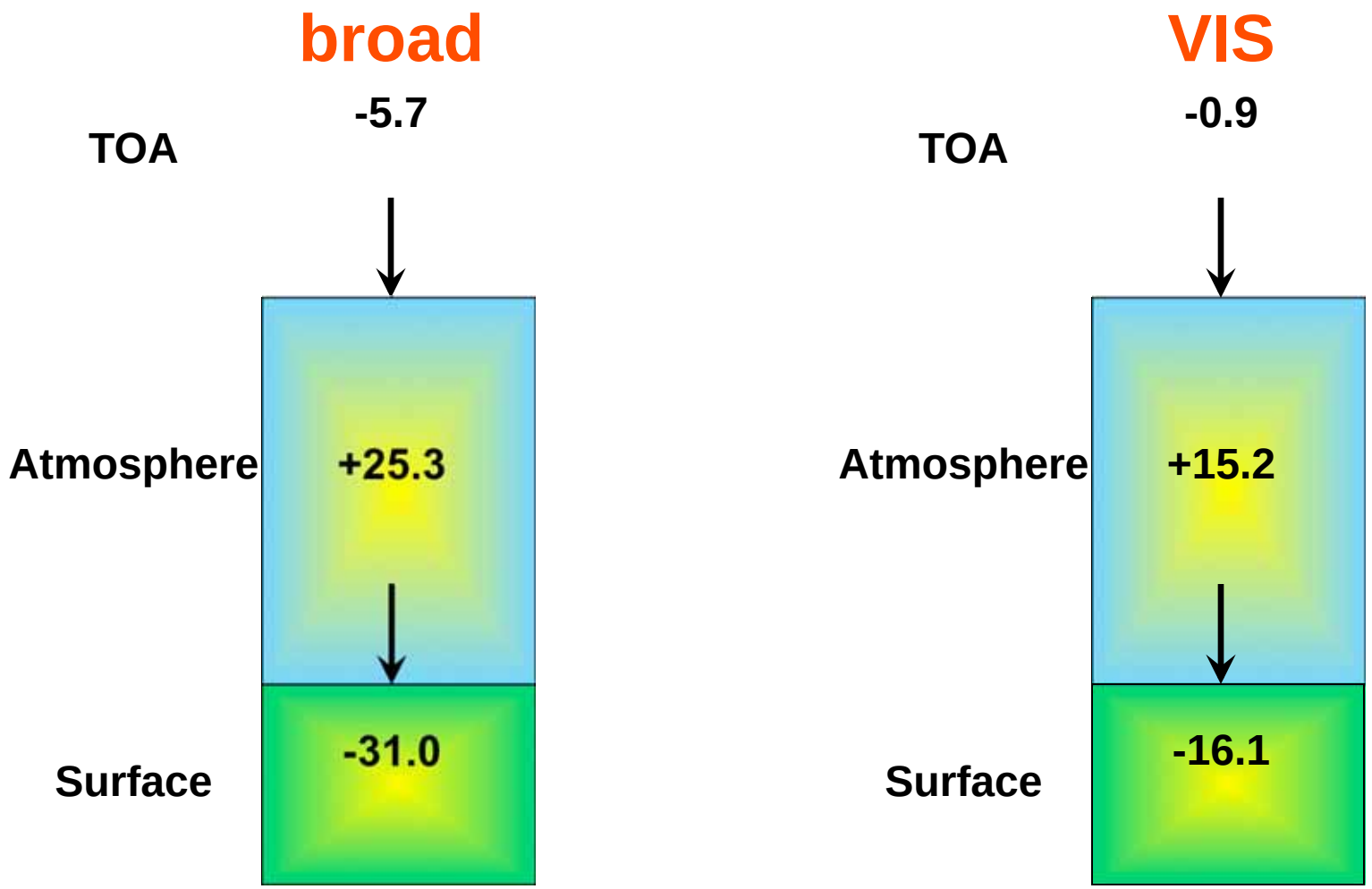
Measured Absorption over Dryden (July 10, 2008)



Measured vs. Simulated Absorption

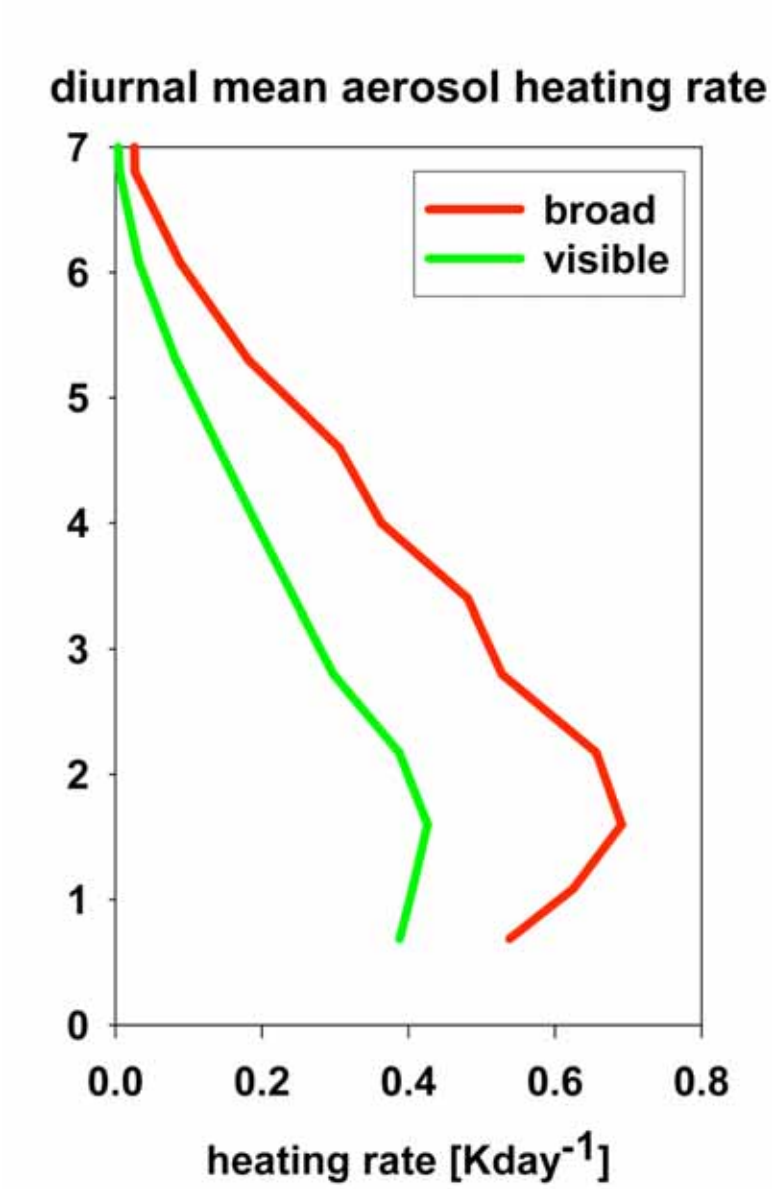


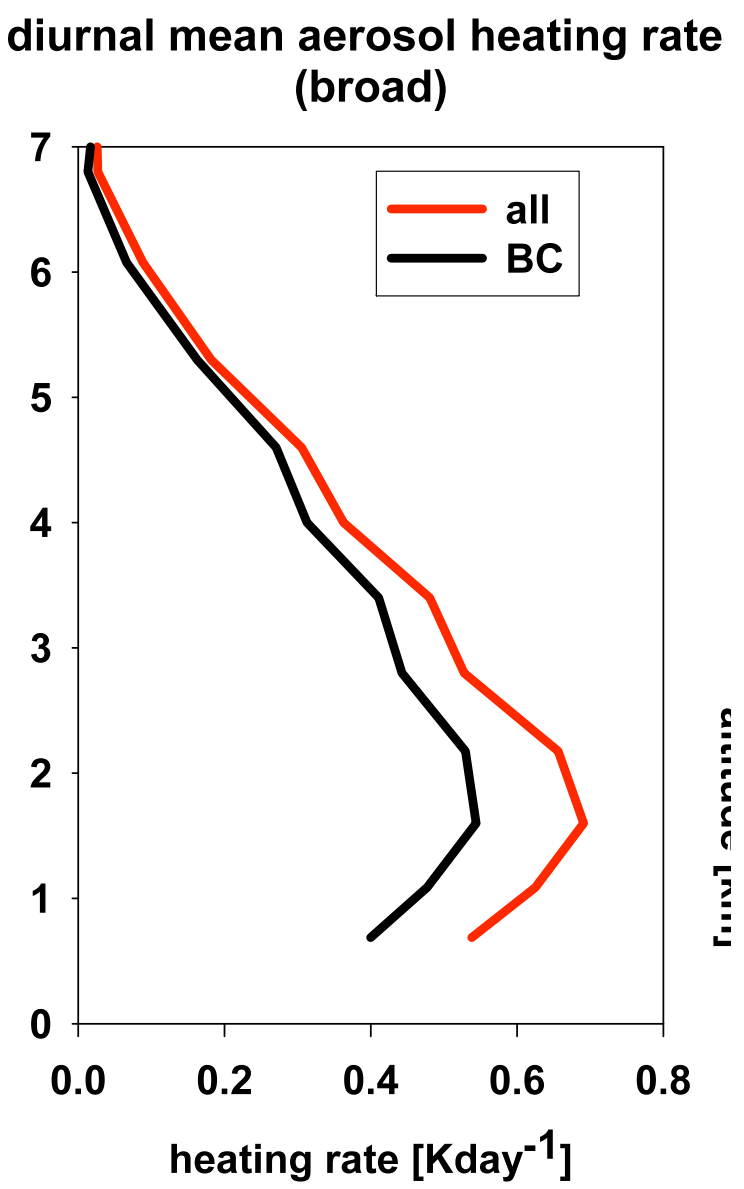
CAPPS forcing



Note: number indicates aerosol induced radiative forcing [Wm-2] at top-of-atmosphere (TOA), atmosphere, and surface. Numbers inside the parenthesis are the percentage of aerosol forcing relative to background atmosphere (without aerosols)

Atmospheric Heating Rates during Wildfires





Conclusions

- Direct measurements of aged wildfire plumes were used to validate radiative forcing estimates.

- The aerosols generated by a wildfire plume (AOD = 1) absorb solar radiation by 25 W/m^2 and heat the atmosphere by ~ 0.6 K/day in the lowest 3km of the atmosphere.

- Black carbon accounts for 80% of aerosol heating in the plume with the remaining 20% being attributed to dust and organic carbon.

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